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Project Summary

Measurement of Cadmium, Lead, Zinc, and Calcium in Selected Populations in the United States

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ORIGINAL

As part of a continuing national and international survey of cadmium (Cd) ingestion, a study was performed to estimate the daily intake of Cd and other metals in two low-income populations in the United States: rural blacks and urban Hispanics of Mexican-American heritage. More than 260 persons were recruited and surveyed. Feces, urine, and blood were collected from each participant and analyzed for Cd, Pb, Zn, Ca, and Fe; blood was also analyzed for Fe-binding capacity and hemoglobin; and urine was also analyzed for beta$_2$-microglobulin and creatinine.

Results indicate that ingestion rates of Cd in both populations are slightly lower than levels reported previously for the general population of the United States, and ingestion rates of Pb are considerably lower (less than one-half) than levels reported previously for the general population. It was concluded that nonoccupational exposures of these two population groups to Cd and Pb through ingestion is no greater than and is probably less than that experienced by the general population of the United States.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Neither cadmium (Cd) nor lead (Pb) has any biochemical function essential to good health. Both metals are toxic at low concentration, Cd more so than Pb.

The half-life of Cd and Pb in the body is estimated to range from 5 to 30 years. Increased accumulation of Cd in the body will eventually lead to proteinuria, renal tubular damage, kidney failure, osteomalacia, and nerve dysfunctions. Elevated accumulations of Pb in the body may lead to anemia, gastrointestinal dysfunctions, encephalopathy, neuropathy, and nephropathy. The "target" organ for Cd is the kidney while bone appears to be the "target" organ for Pb.

Industrialized countries have continually increased their use of Cd and Pb which has resulted in an increased risk-of-exposure for both occupationally and nonoccupationally exposed populations. This increased risk-of-exposure comes from both industrial products and pollution. Industrial pollution has increased the concentration of these metals in water, air, soil, and food. Atmospheric pollution of Cd and Pb is expected to increase in the United States, as coal and lignite replace petroleum feedstocks as our major energy sources. Another important source of Cd and Pb exposure is cigarette smoking, which statistics indicate is increasing in teenagers and women. One pack of cigarettes contains the equivalent of 25 μg of Cd from dietary sources when relative absorption rates are accounted for. It is estimated that smoking 30 cigarettes per day will provide an average of 15 μg of absorbed Cd to the body.

Investigations of acute exposure episodes to Cd pollution have stimulated an interest in the biochemistry of Cd and have focused attention on the health

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effects caused by long-term exposure to low concentrations of Cd in the diets of different populations. Recent studies on Pb pollution have been concerned with the health effects caused by exposure to exhaust fumes from the combustion of leaded gasolines and from point sources, such as lead smelters, coal-fired power plants, and battery reclamation plants.

The application of sewage sludge to crop lands has been practiced for many years in this country. Presently, about 25 percent of all municipal sludges are applied to land. This presents another source of toxic metals to the environment and a direct link with the food chain when applied to crop lands.

Because Cd and Pb are accumulated by certain vegetables and grain crops, and dietary intake is a major source of exposure to the general population, the risk of increased exposure to these metals is a reflection of the increased contamination of the environment. The average daily ingestion via food in noncontaminated areas has been estimated to range from 10 to 50 μg for Cd and between 100 and 500 μg for Pb. Using a "market basket" approach, the U.S. Food and Drug Administration has estimated the median American diet to contain 39 μg of Cd per day. Recent studies in nonindustrially polluted urban areas of the United States have estimated daily dietary intake of Cd to range from 12 to 24 μg/day by measuring Cd in human feces. It has been estimated that adult Americans absorb 29 μg of Pb every day from atmospheric and dietary sources.

Absorption percentages for Cd and Pb are estimated to be only 4 percent and 9 percent (approximate), respectively, and these absorption percentages are influenced by various dietary factors. Studies have indicated that vitamins, minerals, and other trace metals can influence the absorption of Cd and Pb. For example, levels of calcium (Ca), copper (Cu), iron (Fe), zinc (Zn) and vitamin C in the diet will affect the absorption rate of Cd and Pb. Elevated absorption rates due to Fe deficiency, protein deficiency, or decreased levels of Ca in the diet could provide tissue exposure to Cd and Pb at toxic levels from diets that are otherwise within normally acceptable limits.

Because estimates of daily ingested rates approach recognized toxic levels, the quantities of Pb and Cd ingested by the population of the United States are of concern. Some studies have provided estimates for Cd and Pb by a "market basket" approach and by measurement of the metals in human feces. More data are needed to assess possible effects of geographic, socioeconomic, ethnic, sex, and urban-versus-rural differences. Three high risk groups have been identified among the various population groups within the United States. These are vegetarians, high-rate consumers of shellfish, and poor black and Hispanic populations. This study was designed to survey ingestion rates and associated health effects in the latter group. The survey addresses two very specific population groups: low socioeconomic rural blacks and low socioeconomic urban Hispanics. These populations were thought to be potentially at higher risk than the general population because low socioeconomic status limits the ability to select certain foods and provides a bias for grains, grain products, and vegetables known to contain higher levels of Cd. Food preferences in the two ethnic groups may also provide a further tendency for consumption of the higher Cd foods. This tendency may be accentuated for blacks in rural areas where traditional food preferences may be less affected by recent social changes.

A number of very distinctive Hispanic populations are residents in various areas of the United States. These include persons of Mexican heritage, Puerto Rican heritage, Cuban heritage, and others. It is recognized that no one of these heritages is completely representative of all persons of Hispanic heritage residing in the United States. However, to provide the study with some degree of homogeneity in the selected Hispanic population, only one of these heritages was utilized—persons of Mexican-American heritage. Persons of Mexican-American heritage are the most numerous among the various nationalities of the Hispanic populations in the United States, they are more widely dispersed among the various states and regions of the United States, and there continues to be a greater influx of Hispanic immigrants from Mexico than from any other source of Hispanic populations.

Objectives

The general objective of this study was to estimate the ingestion rates of Cd and Pb in two subgroups of the population of the United States, low socioeconomic rural blacks and low socioeconomic urban Hispanics, and to evaluate the evidence of Cd toxicity. The specific objectives to accomplish this general objective were:

1. select specific study populations from the two subgroups of the population of the United States;
2. obtain fecal, blood, and urine samples and diet, health, and smoking history information from the selected study population;
3. measure levels of Cd and Pb in the fecal samples and estimate daily ingestion rates;
4. measure levels of Cd and Pb in the urine and blood samples to provide data relative to recent exposures and to estimate body burdens;
5. measure levels of Ca and Zn in the fecal samples to evaluate the possible effect on Cd status;
6. measure Fe in feces and serum, total Fe binding capacity, and hemoglobin to evaluate Fe deficiency;
7. measure $beta_2$-microglobulin in urine to evaluate for evidence of Cd toxicity. It has been shown that during Cd-induced proteinuria there are large excretions of $beta_2$-microglobulin. Elevations of protein have been seen in populations with high fecal and urinary levels of Cd;
8. measure creatinine and specific gravity levels in urine for use in adjusting urinary parameters for urine concentration; and
9. determine significant patterns regarding ingestion rates, body burdens, Fe deficiency, and Cd toxicity in the study populations with regard to ethnicity, age, sex, smoking history, and dietary habits and compare these findings to results for the general population of the United States.

Design

The design of this study was to recruit 240 participants, 120 in each of two population subgroups in the United States as shown in the following table:

Sex	Age	Number of Participants: Urban Hispanics	Number of Participants: Rural Blacks
Male	Young 12-18	30	30
	Old 50+	30	30
Female	Young 12-18	30	30
	Old 50+	30	30
		120	120

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The study populations were focused into two age groups to provide some homogeneity regarding age and age-related potentially confounding factors. Age is an important characteristic which influences exposure levels due to lifestyles and eating habits and which is related to susceptibility. The increase of Cd levels in tissue with increasing age is well documented. In order to provide the opportunity for observing differences related to age, two age groups were selected: a young age group ranging 12 to 18 years and an older age group of 50 or more years. The ages of 12 to 18 years are important growth years with high consumption of foods and building of much tissue, potentially Cd-laden. Because tissue Cd is known to increase with age, the older group is considered to have a high susceptibility to continued Cd exposure. Selection of these two age groups provided a study population with high susceptibility and with a sufficient spread in ages for observation of age effects.

Census statistics were used to select one urban and one rural community as study sites to provide sufficient numbers of low socioeconomic populations of the required ethnic types. Within each selected study site, specific recruitment areas were designated which exhibited particularly uniform socioeconomic and ethnic characteristics of the desired types. In general, all residents of the designated recruitment areas who met age and ethnic requirements were considered eligible.

Study participants were recruited through personal contacts by trained recruiters. Use was made of civic organizations, church groups, and schools in the selected study sites. Potential volunteers were met at schools or community centers and briefed on the objectives of the study. Informed consent was obtained through the use of a specially designed form. Volunteers were provided a package that contained sample collection containers for urine and feces samples and instructions for storage. Blood samples were collected by medically trained and licensed personnel at the school or community center. Study participants collected and stored urine and feces samples over a weekend and delivered the samples to the study team on the following Monday. Health, dietary, smoking, and personal background information were collected from each participant via interview with use of a specially designed health history record form.

Each participant provided the following samples: two 10-ml vacutainers of blood; two 24-hour stool samples; and one 24-hour urine sample. The following measurements were performed on the samples collected:

Sample Type	Analysis
Feces	Cd, Pb, Zn, Ca, Fe, and weight
Blood	Cd, Pb, Fe, total Fe-binding capacity, and hemoglobin
Urine	Cd, Pb, beta$_2$-microglobulin, specific gravity, creatinine, and volume

The study was conducted during an 18-month period, beginning February 1980. Samples were collected during the period June to October 1980.

Conclusions

An important objective of this study was to determine the ingestion rates of Cd and Pb in two specific population groups in the United States, urban Hispanics and rural blacks, to compare these levels to levels previously reported for the general population of the United States, and to determine whether these two population groups are at high risk to these toxic metals. Study results are similar for the two study populations. Ingestion rates of Cd in both populations are comparable to but slightly lower than levels reported previously for the general population. Ingestion rates of Pb are considerably lower (less than one-half) than levels reported previously for the general population. It is concluded from the results that nonoccupational exposures of these two population groups to Cd and Pb through ingestion is no greater than, and is probably less than, that experienced by the general population of the United States. Thus, it appears that the original hypothesis that the two population groups are at higher risk of ingesting large quantities of these toxic metals is false. In the context of Cd and Pb, their diet patterns are probably no different from those of the general population of the United States.

A second important objective of the study was to evaluate the evidence of Cd toxicity. It is concluded from the study results that little or no evidence of Cd toxicity has been found for either of the two study populations.

In addition to these major conclusions, a number of secondary conclusions have been drawn from the study:

1. There is no apparent Fe deficiency in either of the study populations.
2. Smokers tended to exhibit higher levels of urine Cd than nonsmokers in both study populations.
3. Food consumption habits in both study populations do not appear to be oriented to the higher Cd foods.
4. A relatively high rate of heart disease and high blood pressure was self-reported by the older black female study population.
5. A relatively high rate of kidney disease was reported by the older black populations.
6. No correlation with Cd levels in blood, urine, or feces was detected for the populations with higher reported heart disease, blood pressure, or kidney disease.
7. Because no unusually high Cd levels were found in the study populations, the potential for Zn or Ca compounds to influence Cd status was not addressed.

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The complete report, entitled "Measurement of Cadmium, Lead, Zinc, and Calcium in Selected Populations in the United States," (Order No. PB 85-127 165; Cost: $13.00, subject to change) will be available only from:
National Technical Information Service
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